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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project, Technical Specification Group Terminals.

The contents of the present document may be subject to continuing work within the 3GPP and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released with an identifying change of release date and an increase in version number as follows:

Version m.x.y

where:

- m indicates [major version number]
- x the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- y the third digit is incremented when editorial only changes have been incorporated into the specification.

Introduction

When UMTS is launched the coverage will be very limited in many areas while several second-generation systems will have a very wide coverage. To make UMTS useful for a wide range of users from the start, multi-mode UEs, combining e.g. second-generation radio access system with UMTS, are necessary. The present document describes the work done in other working groups within 3GPP and SMG concerning multi-mode UEs.

1 Scope

This 3GPP Technical Report identifies the work done in other working groups within 3GPP and SMG concerning Multi-mode UEs. The report is related to TR 21.910 [38] which identifies multi-mode User Equipments categories and also describes the general principles and procedures for the multi-mode operation standardised in the 3GPP specifications.

The present report describes the status of the work as of February 2000.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] 3G TS 23.122: “NAS Functions related to Mobile Station (MS) in idle mode” v3.2.0

[2] 3G TS 25.304: "UE Procedures in Idle Mode" v1.2.0

[3] 3G TS 22.129: "Handover Requirements between UMTS and GSM or other Radio Systems" v3.2.0

[4] 3G TR 21.905: "Vocabulary for 3GPP Specifications " v1.0.0

[5] 3G TS 22.011: “Service accessibility” v3.1.0

[6] 3G TS 25.303: "UE Functions and Interlayer Procedures in Connected Mode" v3.0.0

[7] TS GSM 05.08: “ Digital cellular telecommunications system (Phase 2); Radio subsystem link

[8] 3G TS 22.100: “UMTS phase 1 Release 99” v3.3.0

[9] 3G TS 22.101: “Service aspects; Service principles” v3.6.0

[10] 3G TS 23.121: "Architectural Requirements for Release 1999" v3.8.0

[11] 3G TR 23.920: "Evolution of the GSM platform towards UMTS" v3.1.0

[12] 3G TS 33.102: “Security Architecture” v3.3.0

[13] 3G TS 32.102: “3G Telecom Management architecture” v3.0.0

[14] 3G TS 25.201: “ Physical layer - General description” v3.0.0

[15] 3G TS 25.215: “Physical layer – Measurements (FDD)” v3.0.0

[16] 3G TS 25.225: “Physical layer – Measurements (TDD)” v3.0.0

[17] 3G TS 25.832: “Manifestations of Handover and SRNS Relocation” v3.0.0

[18] 3G TR 25.931: “UTRAN Functions, Examples on Signalling Procedures” v1.2.2

[19] 3G TR 25.942: “RF System Scenarios” v2.0.0

[20] 3G TS 25.103: “ RF Parameters in Support of Radio Resource Management” v2.0.0

[21] 3G TS 25.123: “Requirements for Support of Radio Resource Manage

[22] 3G TS 25.133: “Requirements for Support of Radio Resource Management (FDD)”

[23] 3G TS 23.009: “Handover procedures” v3.1.0

[23] TS GSM 03.60: “General Packet Radio Service (GPRS); Service description; Stage 2”

[24] 3G TS 24.007: “ Mobile radio interface signalling layer 3; General aspects” v3.2.0

[25] 3G TS 24.008: “Mobile radio interface layer 3 specification, Core Network Protocols - Stage 3” v3.2.1

[27] 3G TS 23.060: “General Packet Radio Service (GPRS); Service description; Stage 2” v3.2.1

[28] 3G TS 27.060: “Packet Domain; Mobile Station (MS) supporting Packet Switched Services” v3.3.0

[29] 3G TS 27.001: “General on Terminal Adaptation Functions (TAF) for Mobile Stations (MS)” v3.3.0

[30] 3G TS 27.002: “Terminal Adaptation Functions (TAF) for services using asynchronous bearer capabilities” v3.2.0

[31] 3G TS 27.003: “Terminal Adaptation Functions (TAF) for services using synchronous bearer

[32] 3G T1 iWD-001: “Interim Working Document; Combined testing areas for RF and Signalling; Idle mode operations, handover and measurement reporting “ v0.2.0

[33] 3G TR 21.904: “Terminal Capability Requirements” v1.2.0

[34] 3G TS 21.111: “USIM and IC Card Requirements” v3.0.0

[35] TS GSM 03.22: “Functions related to Mobile Station (MS) in idle mode and group receive mode”

[36] TS GSM 04.18: “Mobile radio interface layer 3 specification, Radio Resource Control Protocol”

[37] TS GSM 04.60: “Mobile Station (MS) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol”

[38] 3G TR 21.910: “Multi-mode UE Issues - Categories, principles and procedures”

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions apply:

Active communication: a UE is in active communication when it has a CS connection established. For PS active communication is defined by the existence of one or more Activated PDP contexts. Either one or both of the mentioned active communications may occur in the UE.

Camping on a cell: The UE is in idle mode and has completed the cell selection / reselection process and has chosen a cell. The UE monitors system information and (in most cases) paging information. See 3G TS 23.122 [1] and 3G TS 25.304 [2].

Multi-mode UE: UE that can obtain service from at least one mode of UMTS, and one or more different systems such as GSM bands or possibly other radio systems such IMT-2000 family members. [3]

Radio Access Mode: Mode of the cell, FDD or TDD [4]

Radio Access Technology: UMTS, GSM etc [4]

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CC	Call Control
CS	Circuit Switched
FFS	For Further Study
GMM	GPRS Mobility Management
HO	Handover
LA	Location Area
LU	Location Update
MM	Mobility Management
MMI	Man-Machine Interface
PS	Packet Switched
RA	Routing Area
RAT	Radio Access Technology
RR	Radio Resource
RRC	Radio Resource Control
SM	Session Management
URA	UTRAN Registration Area

Additional definitions and abbreviations can be found in TR 21.905 [4].

4 Ongoing work and identified additional work

This section tries to collect all relevant documents related to multi-mode UE issues and reviews the multi-mode UE aspects in them. In some cases additional work has been identified.

The list of document may not be complete but more relevant documents might reside within the groups.

The status of work reported in this annex is as of February 2000.

4.1 TSG SA

In SA there is one document that collects all requirements for R99 that are set by the different WG:s within SA, TS 3G 22.100 [8]. The requirements on Multi-mode UE:s can be found in ch 8 and reads as follows:

> "UMTS phase 1 shall support dual mode UMTS/GSM terminals. At least one Capability Class shall be standardised for mobile terminals supporting the GSM and UTRA modes. It shall support monitoring of cells belonging to the two types of access networks in idle mode (cell reselection procedure) and active mode (handover preparation procedure)."

This corresponds to a type 2 UE as defined in this report. The requirement does not exclude any other types of terminals as those defined in this report

4.1.1 SA1

4.1.1.1 Service requirements

The service requirements for release 99 is collected in TS 3G 22.101 [9]. The requirement related to Multi-mode UE:s can be found in ch. 17 (Handover requirements) and ch 18 (Network selection).

The handover requirements are very general and states that:

> "Any handover required to maintain an active service while a user is mobile within the coverage area of a given network, shall be seamless from the user's perspective. However handovers that occur between different radio environments may result in a change of the quality of service experienced by the user.
>
> It shall be possible for users to be handed over between different UMTS networks subject to appropriate roaming/commercial agreements.
>
> Handover between UMTS and GSM systems (in both directions) is required, even if this requires changes to GSM specifications. In addition, a generic solution may be implemented in UMTS which allows calls to be handed over between UMTS and other pre-UMTS systems in both directions."

The initial requirements for network selection that are relevant for Multi-mode UE:s are:

> "Three roles may be involved in UMTS network selection: the home environment, the serving network and the user. Services may be available to the user through a choice of several serving networks in a given location, possibly using different types of Radio Access Network. However it is expected that a user terminal will communicate with one network at a given instant (there may be exceptions such as when an inter-network handover occurs). "

Even more relevant for the UE and user is how the network selection shall be performed. For that three selection procedures are defined: a default automatic procedure, a manual procedure and a home environment specific procedure. The first two shall be implemented in all UMTS UE:s. As the multi-mode UE defined in this report shall include UMTS, these requirements is valid also for a multi-mode UE. This is also stated in this report for all types of UE:s and can be considered to be in line with the requirements.

A requirement that may affect the specified types of UE in this report is:

> "If simultaneous access to more than one home environment is required (through a card with multiple USIMs or through several cards in a multi-slot terminal), manual selection shall be invoked."

The type 3 UE should be able to camp on several cells from different radio access technologies that are belonging to different operators/PLMN:s at the same time and still an automatic switching between modes are defined for this types of terminal. This has to be considered in later releases of the report. Either the definition of this type of terminal has to be changed or the requirement has to change. The type 3 terminal is not of highest priority for R99 and therefore this is left FFS.

4.1.1.2 Handover requirements

TS 3G 22.129 [3] is a specification that only deals with handover requirements, both within UMTS and between UMTS and GSM. The requirement for handover from UMTS to GSM can be found in clause 6 and the requirements for handover from GSM to UMTS can be found in clause 7.

The requirements for handover from UMTS to GSM are divided into operational, performance and service requirements. The requirements most affecting the UE are those in the performance clause, which include Detection Time of Potential GSM Handover Candidates, Number of GSM handover candidates to detect, Probability of Connection Loss and Temporary degradation of service caused by handover. As a summary it can be said that the requirements that is set for intra-GSM handover shall be applied even when handover from UMTS to GSM. More stringent requirements than that are not set. These requirements mostly affects the radio part of the Multi-mode UE and some of the specifications for that can be found in clause 7.2 in this report.

In the clause with service requirements there are no specific requirements except for the speech, USSD and data bearer service. These services should be continued after a handover. An example of a service that may be interrupted after a handover is the facsimile service.

For the speech service it is said:

> "any call based on the default UMTS speech codec shall be mapped to the FR GSM speech codec. In the case the terminal and the GSM network support AMR and /or EFR and/or HR, it shall be the operators choice to define the appropriate mapping."

For USSD it is said:

> "The technical standards shall provide means to ensure that any handover that occurs during a USSD interaction need no more affect the service than intra-GSM handover."

For the data bearer service it is said:

> "Standards shall be defined to permit the possibility of handover of a UMTS connection oriented data bearer service to GSM which shall result in an appropriate GSM/GPRS bearer service. The mapping between UMTS data bearer services and appropriate GSM/GPRS data bearer services will depend upon many factors such as data rate, delay constraints, error rate etc. Means shall be provided for the application to indicate minimum acceptable QoS for service continuation after handover."

In the clause with requirements for handover from GSM to UMTS mostly just requirements for services are dealt with. The services that should continue after a handover are speech, USSD, a circuit switched data service mapped onto a UMTS packet switched data service and a data switched packet service (if not the change of QoS is too big to be accepted by the user).

When using multiple bearer services in GSM/GPRS it is said that:

> "Consideration must be given to multimedia services which may involve the use of multiple bearer services. For example Class A GPRS terminals will be capable of simultaneously supporting more than one data bearer services. The mapping between GSM/GPRS data bearer services and UMTS bearer services will depend upon many factors such as data rate, delay constraints, error rate etc. Means shall be provided to allow handover of several data bearer services from GSM to UMTS. Means shall be provided for the application(s) to indicate minimum acceptable QoS for services continuation after handover."

These service requirements shall apply for all multi-mode UE:s that supports these kind of services.

4.1.2 SA2

4.1.2.1 Architectural requirements on UMTS for release 99

3G TS 23.121 [10] describes the architectural requirements on UMTS for release 99.

This specification divides connections into if they are in the CS or in the PS domain. The division between GSM and UMTS radio access technology is not so obvious for the core network. From an architectural point of view the division between the CS and PS domain are more important.

Data retrieval between UMTS and GPRS is dealt with in ch. 4.2.2.1. There is even a proposed solution how it shall be done.

The MM procedures for UMTS are described in section 4.3. In section 4.3.1.1 there is a requirement for the R99 UE to support both combined and separate update mechanisms between CS and PS services. The background is that in GSM/GPRS combined updates between RA and LA can be made via the Gs interface between MSC/VLR and SGSN. This possibility is facilitated to optimise the radio resources. As said before, in UMTS it is suggested to use both separate and combined updates for R99 UE:s.

In ch 4.3.14.3 there is a small comparison between MM for UMTS and GSM. The reason for the comparison is to see if the same signalling can be used and how the MM messages should be transferred when handover. If a combined update between GSM and UMTS can be done is in a way studied in TR 23.920 [11] as described further down.

Chapter 6 is totally devoted to the questions on interoperability between GSM and UMTS. In the beginning a recommendation of combined updates if a UE is supporting simultaneous ISDN/PSTN and packet services is made. Otherwise the chapter deals with the signalling procedures for handover between UMTS and GSM. The only thing that is affecting the terminal is where the decision of the handover is performed. For CS services the decision is taken in RNS for UTMS to GSM handover and in BSS for GSM to UMTS handover. For PS services the decision can be made in either the UE, the BSS or in the SRNS. This applies for both directions of handover. In this case the details for how the decision shall be made is FFS.

4.1.2.2 Additional architectural requirements

3G TR 23.920 [11] collects architectural requirements that are not yet accepted or stable enough to be included in the other architectural specification, 23.121.

A small section on the procedures for ciphering keys is included in ch. 5.5.2 and deals with the case of UMTS-GSM handover. The actual interoperation in the case of different ciphering keys for UMTS and GSM are for further study. This does not directly affect the UE but rather the USIM.

Dual-mode operation between UMTS and GSM when the GSM part of the UE is a MS of GPRS class A is handled in chapter 5.8. The section deals with questions of MM procedures and availability of PS services after a handover of a CS service from one of the radio access technologies to the other. The suggestions include letting the UMTS MM to do distinction between CS and PS services in the registration related procedure. The requirements on the MS/UE are that it must be capable of handling the GSM-UMTS dualism, i.e. to be a multi-mode UE.

The UMTS Mobility Management (UMM) for R99 shall use packet anchoring at the GGSN. This implies that some changes have to be introduced in GPRS. In section 5.9.5.4 the affects the requirements of QoS when using the anchor concept and the UE/MS described above (a dual-mode UE with a UMTS part that supports simultaneous CS and PS services combined with a GPRS class A MS) is described. There are no specific requirements on the multi-mode UE and all suggested changes reside in the network.

A definition on simultaneous mode has been made in chapter 5.17. It is defined as:

> "Simultaneous mode is defined as the support of active parallel CS and PS communications.
>
> The UE has simultaneous PS MM Connected and CS MM Connected states when in UE simultaneous mode."

In this section it is also stated that it is important that from day one of UMTS launch supply terminals that supports simultaneous active communication with both the CS and the PS domain. This requirement only applies for and within UMTS but puts special requirements on the UE in respect to terminal capabilities.

Chapter 5.18 deals with the question on GSM and UMTS cells in the same registration area. This could save a lot of signalling when changing between UMTS and GSM, as also described and asked for in the scenarios (chapter 5.1.5). One reason for introducing this is, as stated in [11], that:

> "Third generation needs to offer higher quality (eg higher MT call success rate) than second generation. Hence the capability to have GSM and UMTS cells in the same Registration Area is needed for at least CS traffic."

Some open issues still reside for implementing GSM and UMTS in the same registration area and these are questions on security, network service capabilities, terminal capabilities, idle mode control and the capacity of paging channels, as described in TR 23.920 [11].

In the end of 1999 it was decided that this report had served its purpose and that no updating would be performed thereafter. As this is the case, the report can not be referred to for actual procedures but rather as a source for inspiration for further development of the UMTS architecture. Some of the ideas described above could be feasible to use to make the multi-mode UE operation efficient and if so they should be included in specifications within SA2.

4.1.3 SA3

In SA3 there has been discussion on the issue of fraud in the event of intersystem HO/intersystem change 3G-2G and vice versa. The possibility of the end-user to affect the change of system, to log the HO and to choose whether HO overall is possible. These issues are still under discussion.

4.1.3.1 TS 33.102; Security Architecture V3.3.0

TS 33.102 [12] describes the security features and the security mechanisms for 3G. The section interesting to multi-mode UE issues is section **6.8 Interoperation and handover between UMTS and GSM**, intersystem handover for CS services from UTRAN to GSM BSS and vice versa is described as is also intersystem change for PS services.

Section 6.8.3 Intersystem handover for CS Services-from UTRAN to GSM BSS

There are two handover cases distinguished: 1) Handover to a GSM BSS controlled by the same MSC/VLR and 2) handover to a GSM BSS controlled by another MSC/VLR. For these two handover cases it is explained how the UE derives and applies the GSM cipher key Kc for UMTS and GSM security contexts respectively.

Section 6.8.4 Intersystem handover for CS Services-from GSM BSS to UTRAN

Here there are also two handover cases distinguished: 1) Handover to a UTRAN controlled by the same MSC/VLR and 2) handover to a UTRAN controlled by another MSC/VLR. For UMTS security context the UE applies the stored UMTS cipher/integrity keys CK and IK and for the GSM security context the UE derives the UMTS cipher/integrity keys CK and IK and applies them.

Section 6.8.5 Intersystem change for PS Services-from UTRAN to GSM BSS

For UMTS security context there are three cases distinguished: 1) Handover to a GSM BSS controlled by the same SGSN, 2) handover to a GSM BSS controlled by another R99+ SGSN and 3) handover to a GSM BSS controlled by a R98-SGSN. At the user side in cases 1) or 2) the UE derives the GSM cipher key Kc from the stored UMTS cipher/integrity keys CK and IK and applies it. In case 3) the handover makes that the UMTS security context between the user and the serving network domain is lost. **The UE needs to be aware of that.** The UE then deletes the UMTS cipher/integrity keys CK and IK and stores the derived GSM cipher key Kc.

NOTE Case 3) makes a special demand on the UE, when the UMTS security context is lost. There has to be taken steps to make sure that the UE is implemented to work right in this case SWG5 should clarify if SA3 or T2 is responsible for the right implementation.

For GSM security context two cases are distinguished: 1) handover to a GSM BSS controlled by the same SGSN 2) handover to a GSM BSS controlled by another SGSN. In both cases the UE applies the GSM cipher key Kc that is stored.

Section 6.8.6 Intersystem change for PS services-from GSM BSS to UTRAN

For UMTS security context two cases are distinguished: 1) handover to a UTRAN controlled by the same SGSN 2) handover to a UTRAN controlled by another SGSN. In both cases the UE applies the stored UMTS cipher/integrity keys CK and IK.

For GSM security context two cases are distinguished: 1) handover to a UTRAN controlled by the same SGSN 2) handover to a UTRAN controlled by another SGSN. In both cases the UE derives the UMTS cipher/integrity keys CK and IK from the stored GSM cipher key Kc and applies them.

4.1.4 SA4

SA4 is working on codecs and nothing specific for multi-mode UE issues was found in the documents of SA4.

4.1.5 SA5

4.1.5.1 TS 32.102; 3G Telecom Management architecture V 3.0.0

TS 32.102 [13] deals with the physical architecture for management of UMTS. In section 7.3.1 in figure 2 an overview of the UMTS network element management domains and interfaces is shown. Itf-T is the interface between a terminal and a NE Manager. This interface will in some extent manage the 3G terminal and the USIM of the subscriber. Requirements of this interface are for further study.

4.2 TSG RAN

4.2.1 RAN1

4.2.1.1 Physical layer – general description

The specification 25.201 [14] is the general description of the physical layer in UTRAN.

In chapter 4.2.5, Physical layer measurements, it is stated that the UE shall be able to perform:

> "2) The measurement procedures for preparation for handover to GSM900/GSM1800;"

It also gives an overview of all the other documents produced within RAN1. The documents described below are the most relevant from a multi-mode UE perspective.

4.2.1.2 Physical layer – Measurements (FDD)

TS 25.215 [15] describes the measurements on the physical layer for the FDD mode.

The scope is to establish the characteristics of the physical layer measurements in the FDD mode, and to specify:

- the measurements that Layer 1 is to perform;
- reporting of measurements to higher layers and network;
- handover measurements, idle-mode measurements etc.

Chapter 5.1 describes the measurement abilities for the UE. Among them we have the GSM carrier RSSI which is defined as:

> "Received Signal Strength Indicator, the wide-band received power within the relevant channel bandwidth. Measurement shall be performed on a GSM BCCH carrier. The reference point for the RSSI is the antenna connector at the UE"

UTRAN carrier RSSI is also described in a similar way to the GSM carrier RSSI, as the specification is made for the UTRAN.

The compressed mode, making it possible for the UE camping or in active communication in UMTS to make measurements in other radio access modes/technologies, is described in chapter 6.

These measurements are in line with the, in the present report, definition of a type 2 UE.

4.2.1.3 TS 25.225: Physical layer – Measurements (TDD)

TS 25.225 [16] describes the measurements on the physical layer for the TDD mode.

The scope is to establish the characteristics of the physical layer measurements in the TDD mode, and to specify:

- the measurements that Layer 1 is to perform;
- reporting of measurements to higher layers and network;
- handover measurements, idle-mode measurements etc.

The general measurements concept can be found in chapter 4.1. Chapter 4.2 is describing the measurements for cell selection/re-selection and chapter 4.3 is describing the measurements for handover.

The UE measurement ability is described also in chapter 5.1, including the GSM carrier RSSI. In this chapter an Observed time difference to GSM cell is also defined as:

"Time difference between the Primary CCPCH of the current cell and the timing of the GSM cell"

These measurements are in line with the, in the present report, definition of a type 2 UE.

4.2.2 RAN2

4.2.2.1 UE functions and Interlayer procedures in Connected Mode

In 3G TS 25.303 [6] the functions and Interlayer procedures for a UE in connected mode are described. It starts with defining the UE states and states transitions. The states and states transitions are divided according to if the UE is utilising the CS GSM domain (PSTN/ISDN only) or the GSM/GPRS domain (IP only).

Section 5.6 shortly describes the inter-system handover between UMTS and GSM when simultaneous services in the IP and the PSTN/ISDN domain are used. This procedure requires a terminal with GPRS class A capabilities and no other inter-system procedures for terminals not capable of simultaneous services are described. A GPRS class A MS is not thought to be produced in the nearer future and therefore procedures for other GPRS classes are also needed. Possibly these procedures can be used even if the UE is not connected to both domains at the same time.

The RRC mobility procedures are described not just for FDD and TDD but also for inter-system handover between UMTS and GSM. These procedures are just described for the PSTN/ISDN domain and the procedures for the IP domain are lacking.

4.2.2.2 UE Procedures in Idle mode

In RAN2 another specification dealing with procedures for a UE, 3G TS 25.304 "UE Procedures in Idle Mode" [2], is produced.

The specification shall, according to the scope, include examples of inter-layer procedures related to the idle mode processes and describes idle mode functionality of a dual-mode UMTS/GSM UE. Even so there is no description on how radio access technology shall be chosen. The specification only talks about PLMN selection and reselection. In the section with PLMN selection and reselection (5.1) it is stated:

> "Selection of the radio access system may be part of the PLMN selection and reselection process or it may be a separate process inside NAS *[FFS]*.
>
> *[Note: Details of the possible NAS process of the radio access system selection are out of the scope of TSG-RAN WG2.]"*

The Non Access Stratum (NAS) and the Access Stratum (AS) is a functional division to serve as a basis for the work division between SMG2 UMTS L23 and other groups.

The present report recommends that a specific procedure for choice of radio access technology should be implemented. Some suggestions on how this procedure could be outlined can be found in section 5.1.1.

4.2.3 RAN3

RAN3 is standardising the Iu, Iur, and Iub interfaces. For this report only the Multi-network relevant issues have to be considered (e.g. connection between CN and BSS and/ or RAN).

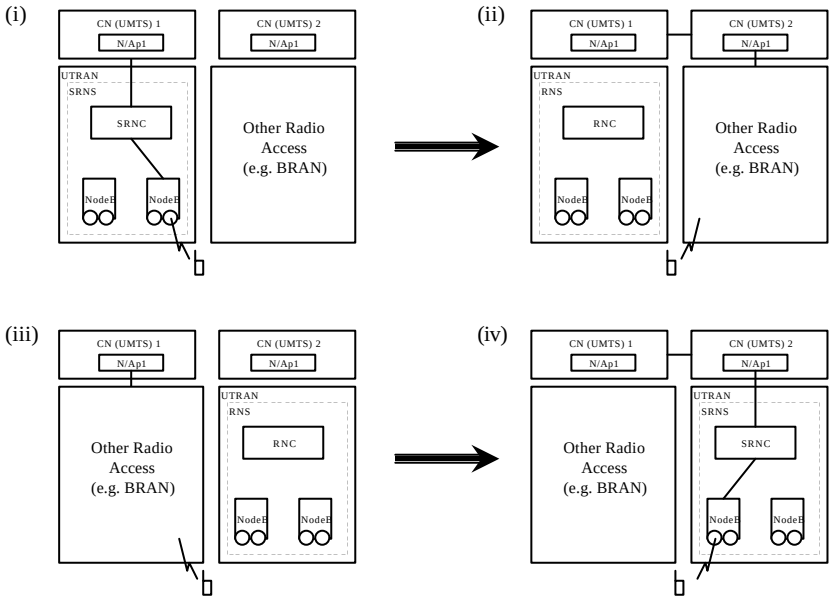
Specific Multi-mode interfaces are not mentioned in the RAN3 documents, nevertheless the HO scenarios are explicitly shown in TS 25.832 [17] and examples of the HO signalling are given in TR 25.931 [18].

4.2.3.1 TS 25.832; Manifestations of Handover and SRNS Relocation

In [17] TS 25.832 chapter 5.5 *Inter CN (different URAN types)* possible HO scenarios between UTRAN and an other 3G access network (e.g. BRAN) are given:

> "This scenario is a combination of the previous two, with the handover between a UTRAN (connected to one UMTS CN) and another radio access (connected to a different UMTS CN; the interface is out of scope of this document). This scenario will note be supported in Release '99. Steps (i) & (ii) show handover from UTRAN. Steps (iii) & (iv)

Note Instead of the sentence "This scenario will note be supported in Release '99" it should be "This scenario will note be supported in Release '99". This is probably a typing error in 25.832. V3.0.0



Inter CN
Different URAN Types

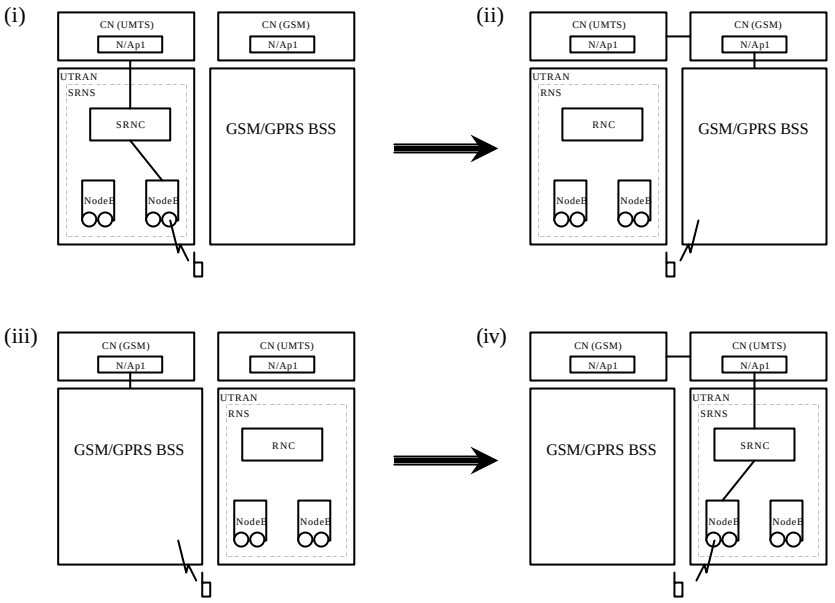
The type of HO (hard/soft) is not mentioned in this chapter, but it can be assumed that only a hard HO is possible.

For this it is necessary to have at least a type 2 Multi-mode UE to fulfil the requirements for this scenarios. A type 1 UE will not be able to send measurement reports to indicate a handover situation to the network or to initiate a handover. This apply to all HO scenarios mentioned in this chapter 7.2.3.

In 25.832 chapter 5.6 *Inter CN (different CN/URAN types)* and chapter 5.7 *Intra CN (UTRAN-GSM/GPRS)* the HO scenarios between UTRAN and a GSM/BSS are shown. Chapter 5.6 gives an example of two different CN connected to each other, while chapter 5.7 assumes a common CN. A scenario in which a GSM network and a UMTS network is run by the same operator is more likely for a situation described in Chapter 5.7.

> "5.6 Inter CN (different CN/URAN types
>
> This scenario shows the case of UMTS-GSM handover. More generally this scenario is for inter core network handover with different URAN types. It will be supported by UTRAN as a hard handover only. It is assumed that there will be no direct UTRAN-BSS interface. Steps (i) & (ii)

show handover from UTRAN. Steps (iii) & (iv) show handover to UTRAN."

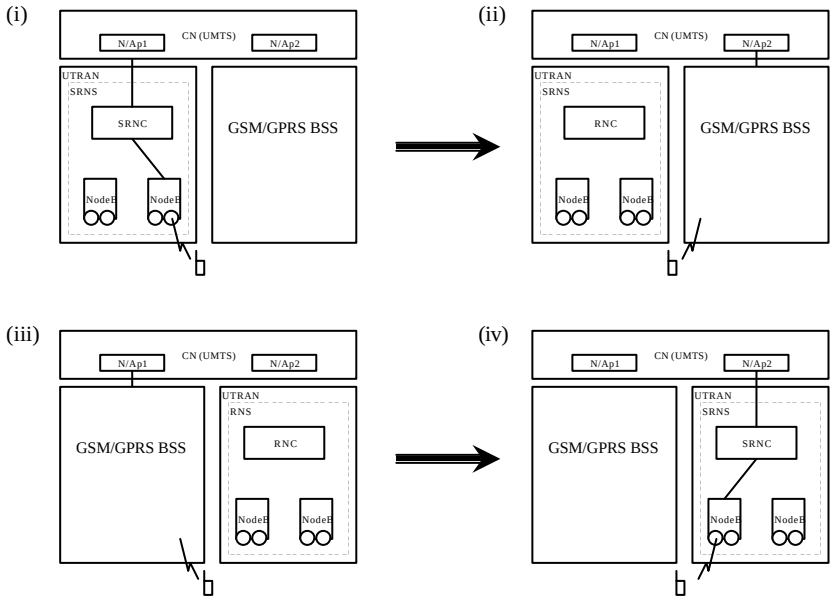


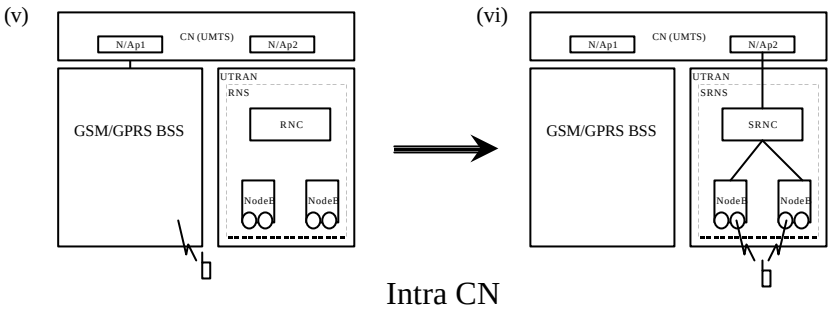
Inter CN
Different CN/URAN Types

"

"5.7 Intra CN (UTRAN-GSM/GPRS)

This scenario shows handover between UTRAN and a GSM BSS. This will be supported by the UTRAN as hard handover only. It is assumed that there will be no direct UTRAN-BSS interface, so handover between GSM BSS and UTRAN is supported by switching in the core network. Steps (i) & (ii) show handover from UTRAN. Steps (iii) & (iv) show handover to UTRAN. Steps (v) & (vi) show an example of the special case of hard handover from GSM to a macrodiversity situation in UTRAN. The ability of the GSM system to support this scenario is for further study, and is out of scope for this report."





Intra CN
UTRAN/GSM

In 25.832 chapter 6 *Applicability of the Scenarios* it is said that the HO between TDD and FDD mode is included in the scenarios already mentioned:

> "Handover between TDD and FDD mode (and vice versa) is a special case of the inter-cell, intra UTRAN or inter UTRAN hard handover scenarios shown above whenever the cells involved are of different modes (FDD or TDD). So, these mixed mode scenarios are already included in the relevant scenarios above."

4.2.3.2 TR 25.931; UTRAN Functions, Examples on Signalling Procedures

TR 25.931 [18] chapter 9.15 *HO between UTRAN and GSM/BSS* is dealing with signalling examples for a UMTS and 2G network HO.

As the scope of TR 25.931 defines itself as:

> "This document describes the UTRAN functions by means of signalling procedure examples (Message Sequence Charts). The signalling procedure examples show the interaction between the UE, the different UTRAN nodes and the CN to perform system functions. This gives an overall understanding of how the UTRAN works in example scenarios."

they should only be regarded as signalling examples. This is also stated in chapter 9 *UTRAN Signalling Procedures*:

> "The signalling procedures shown in the following sections do not represent the complete set of possibilities, nor do they mandate this kind of operation. The standard will specify a set of elementary procedures for each interface, which may be combined in different ways in an implementation. Therefore these sequences are merely examples of a typical implementation."

Chapter 9.15.1 gives the overview of the UTRAN -> GSM/BSS HO, 9.15.2 the overview for the vice versa scenario (GSM/BSS -> UTRAN) and chapter 9.15.3 the overview for the GPRS-> UTRAN HO scenario.

Examples for the UTRAN->GPRS UE initiated HO are given in chapter 9.15.4 and examples for the Network initiated HO are shown in chapter 9.15.5.

4.2.4 RAN4

4.2.4.1 RF System Scenarios

The RAN4 report, 25.942 [19], describes the RF System Scenarios. It is/has been used when defining UTRAN and the scope states:

> "During the UTRA standards development, the physical layer parameters will be decided using system scenarios, together with implementation issues, reflecting the environments that UTRA will be designed to operate in."

No scenarios describing the effects of combined UTRAN and GSM environment is present in the report.

4.2.4.2 RF Parameters in Support of Radio Resource Management

Another document produced by RAN4 is 25.103 [20]. This specification describes the RF parameters in support of radio resource management (RRM). Section 6.1.4 in this specification treats the RRC Mobility connection for Handover from 3G to 2G. The section describes the UE requirements for performing handover from UMTS to GSM, e.g how many carriers the UE shall be able to monitor and syncronise. The opposite direction is not treated and for that direction references to GSM specifications are made. The main specification to refer to is 04.18 [36].

The document above has been withdrawn and instead two new documents 25.123 “Requirements for Support of Radio 5.133 “Requirements for Support of Radio Resource Management (FDD)” [22] has been created.

Chapter 4.3.2 in TS 25.123 [21] describes the requirements for UTRAN to GSM Cell Re-Selection for idle mode. The chapter describes cell re-selection delay, test parameters and performance requirements. Some information, as the actual time within the cell should be re-selected, is not included yet. Also the test parameters are stated tbd. The handover procedures from 3G to 2G are described in chapter 5.1.3. For the other direction, the GSM specifications have to be referred (se above).

TS 25.133 [22] is describing the support of RRM for FDD and includes a bit more information than TS 25.123 [21]. The idle mode tasks are described in 4.3.3 to 4.3.5 and are divided into cell re-selection delay and test parameters. The text is very much alike the one in TS 25.123 [21] and no test parameters are included here either. The performance requirements for GSM RSSI are in this specification included in chapter 8.1.7.For the handover case from 3G to 2G (clause 5.1.3) the exact same text are included in this specification as in the specification for TDD.

4.3 TSG CN

4.3.1 CN1

The work in CN1 is concentrated around signalling aspects such as MM/CC/SM and signalling over the Iu-interface.

Work done during the CN1-meeting (ad hoc meeting on GSM/UMTS interworking) end of November 1999 were a list with tasks that needed to be completed for R99. The most important of them affecting the UE is how MS/UE classmarks shall be changed and the interworking of the classmarks in the network e.g. at handover, for a multi-mode UE. The discussion has been long and has resulted in the conclusion that the easiest way of implementing the functionality that a multi-mode UE informs the network about its capabilities, is that the classmarks for both GSM and UMTS are sent and stored in the network. This means that no new classmark especially designed for multi-mode UEs will be defined, but the UE and the network will have to store two classmarks instead.

Other interesting subjects on the list were:

- changes to modify GSM-MM+GMM to UMTS-MM+GMM+PMM,
- service continuity between GSM and UMTS, e.g. QoS mapping, handover,
- handling of identities as USIM may contain 3G-IMUI as well as a 2G-IMSI.

The work in CN1 does not affect the terminal itself but produces procedures defining behaviour in the core network that indirectly are related to the UE. One example of that are the handover procedures.

7.3.1.1 Handover procedures

In TS 23.009[23], the functionality for the core network for handover procedures is described. In Section 5 the handover initiation conditions are described.

> “Handover may be initiated by the network based on RF criteria as measured by the MS or the Network (signal level, Connection quality, power level propagation delay) as well as traffic criteria (e.g. current traffic loading per cell, interference levels, maintenance requests, etc.).
>
> In order to determine if a handover is required, due to RF criteria, it is typically the MS that shall take radio measurements from neighbouring cells. These measurements are reported to the serving cell on an event driven or regular basis. When a network determines a need for executing a handover the procedures given in GSM 08.08 [5] TS 25.303 [13], TS 25.331 [14] are followed.”

This section does not consider the case where the UE makes the decision about handover. This is a requirement from SA2 and is requested for certain PS services, see section 6.1.2.1.

4.3.1.2 NAS Functions related to Mobile Station (MS) in idle mode

TS 23.122 [1] are defining functions related to the MS in idle mode. A quote from the scope states that:

> "This TS gives an overview of the tasks undertaken by the Core network protocols of a Mobile Station (MS) when in idle mode, that is, switched on but not having a dedicated channel allocated.. It also describes the corresponding network functions. The idle mode functions are also performed by a GPRS MS as long as no dedicated channel is allocated to the MS.

The specification refers to single mode GSM, single mode UMTS as well as multi-mode GSM/UMTS operation.

The specification includes functions such as "PLMN selection and roaming", "Regional provision of service" (e.g. forbidden LA identities for regional provisioning of service) and "Access control". The first function is most interesting for the work with multi-mode UEs. The PLMN procedures are including the choice of RAT/mode but not as the first priority. The first priority is to choose a PLMN and then the camping will be done in a cell with the best radio performance at the location. The MS shall search for all available RATs/modes specified within each PLMN.

Another interesting subject is also how the location update will be performed. Therefore the description on the Location registration process found in this specification is interesting. The situations that are described are "Initiation of Location Registration", "Periodic Location Registration" and "IMSI attach/detach operation". The main context is that the UE only perform location update when the new cell is in a new location area irrespectively of whether cell changes imply a change of Radio Access Technology/Mode. Similarly apply to the routeing area update.

4.3.1.3 Mobile radio interface signalling layer 3; General aspects

In TS 24.007 [24] the general aspects for layer 3 mobile radio interface signalling are defined. The beginning of the scope reads as follows:

> "This Technical Specification (TS) defines the principal architecture of layer 3 and its sublayers on the GSM Um interface, i.e. the interface between Mobile Station (MS) and network; for the CM sublayer, the description is restricted to paradigmatic examples, call control, supplementary services, and short message services for non-GPRS services. It also defines the basic message format and error handling applied by the layer 3 protocols."

The general aspects are described from the perspective of different types of MS/UE. The list of MSs considered is:

1. Non-GPRS
2. GPRS functionality of class A and B
3. GPRS functionality of class C

These division can be applied even for UMTS and it is not just the PS domain that is described, but the CS also, as it is the terminal categorisation from GPRS that is used.

Further on, the signalling procedures are described for different services in the PS domain. The four service cases described are:

1. for non-GPRS services:
2. for CTS services (in addition to non-GPRS services)
3. for GPRS services supporting Class C MSs :
4. for non-GPRS and GPRS services supporting Class A and Class B MSs :

4.3.1.4 Mobile radio interface layer 3 specification, Core Network Protocols - Stage 3

TS 24.008 [25] are the stage 3 description of the core network protocols for mobile radio interface layer 3 procedures. The procedures currently described in this TS are for the

- call control of circuit-switched connections,
- session management for GPRS services,

- mobility management and radio resource management for circuit-switched and GPRS services.

Even if no specific UMTS terminology is used, the functionality for GPRS is used for the UMTS case too. The whole document is considered for the combination of GSM MSs and UMTS UEs if nothing else is stated (e.g. GSM only). When talking about the PS-domain it is referred to as for GPRS. When using PS-services in GSM only, a GPRS MS may operate in one of the following MS operation modes, see 03.60 [26]:

- MS operation mode A;
- MS operation mode B; or
- MS operation mode C.

As for packet services in UMTS only case, an UE attached to packet switched domain may operate in one of the following MS operation modes, see 23.060 [27]:

- PS/CS mode of operation; or
- PS mode of operation.

In the PS-domain only the network modes I and II are considered as network operation mode III is not applicable for UMTS, see 23.060 [27].

4.3.2 CN2

This group is working with specifications for CAMEL/MAP. The assumptions for their work are that the work should not influence the behaviour of the terminal. Therefore no relevant documents for this work has been found.

4.3.3 CN3

This group is working with specifications for Interworking with external networks. The group itself are divided into two groups, one working with the circuit switched domain and the other working with the packet switched domain. For these domains, the implementation of services are studied and how interworking for the services can be done with other networks. Most work recently have been concentrated around the circuit switched services, e.g. the fax service.

4.3.3.1 Packet Domain; Mobile Station (MS) supporting Packet Switched Services

TS 27.060 [28] is the most important specification from this group that are dealing with the UE.

The scope of this specification reads as follows:

> "The UMTS/GSM PLMN supports a wide range of voice and non-voice services in the same network. In order to enable non-voice traffic in the PLMN there is a need to connect various kinds of terminal equipments to the Mobile Station (MS). The present document defines the requirements for TE-MT interworking over the R-reference point for the Packet Domain, including the protocols and signalling needed to support Packet Switched services, as defined in 3G TS 22.060 and 3G TS 23.060."

A quote from the introduction reads as follows:

> "This document defines the requirements for TE-MT interworking over the R-reference point for the Packet Domain, within the GSM and 3GPP systems. It is up to the manufacturer how to implement the various functions but this specification and existing 3G TS 27.001, 27.002, and 27.003 shall be followed where applicable.
>
> It is the intention that the present document shall remain as the specification to develop a MS for support of Packet Switched services and its text includes references to UMTS/GSM standards."

There are some common functions defined that are needed for all UEs supporting packet switched services. They are divided into Mobile Station Modes of Operation, Physical Interface and Terminal context procedures. The modes of operation defined are as described above in 7.3.1.4. A CS-mode of operation for a UMTS UE is out of scope for the document.

The specification is then divided according to functions that are needed to support specific services. The services described are:

1. X.25 based services
2. IP based services

3. PPP based services

A specific service, IHOSS (Internet Hosted octet Stream Service) is also described and in addition to that all AT-commands that are existing and needed for packet related services.

As for a conclusion, the specification deals with packet based services and the interface to both UMTS and GPRS is considered.

4.3.3.2 Terminal Adaptation Functions (TAF) for Mobile Stations (MS)

TS 27.001 [29], TS 27.002 [30] and TS 27.003 [31]are defining the Terminal Adaptation Functions (TAF) for MSs.

The TAF is used to adapt the MT to TE needed to use even packet switched services in a PLMN. The TAF functionality is thought to be totally included in the MT.

27.001 describes the general aspects for TAF as defined in ITU-T I-series and considers both the UMTS and the GSM domain. This can be viewed in the following text extracted from the specification.

> "This TS is valid for a 2nd generation PLMN (GSM) as well as for a 3rd generation PLMN (UMTS). If text applies only for one of these systems it is explicitly mentioned by using the terms "GSM" and "UMTS". If text applies to both of the systems, but a distinction between the ISDN/PSTN and the PLMN is necessary, the term "PLMN" is used."

27.002 is describing the functionality for TAF for services using asynchronous bearer capabilities. One section (Ch. 5) is totally devoted to the mapping of terminal interfacing to GSM 04.08. Even so, only those elements/messages that are of particular relevance are considered in this section. E.g. mapping of other call establishment or clearing messages to the S interface (e.g. call proceeding) have not been included.

27.003 defines the TAFs for services using synchronous bearer capabilities.

4.4 TSG T

4.4.1 T1

T1 has at present stage an Interim Working Document called "Combined testing areas for RF and Signalling; Idle mode operations, handover and measurement reporting" [32]. The scope of the document states:

> "The purpose of the present document is to be used as a permanent-working document within T1 to elaborate the combined testing areas of RF and signalling. Those areas are:
>
> - PLMN selection/reselection
> - Cell selection and reselection
> - Handover, hard/soft, FDD/TDD, 2G/3G
> - Location Area (LA) and Routing Area (RA) updating (MS idle mode)
> - Cell and UTRAN Registration Area (URA) updating (MS connected mode)
> - Measurement reporting
>
> The present document describes the status of core requirements for conformance testing of Mobile Station idle mode operations. The present document primarily focuses on the MS idle mode operations in a pure 3G environment. However, the scope will be expanded covering also test cases for idle mode operations in the GSM/3G case as soon as possible. "

Section 5.1.3, MS idle mode – Inter Radio Access System selection and cell reselection, containes a table with system scenarios (e.g. Inter Radio Access System cell reselection from GSM to UTRAN; Sucessful cell reselection) and the appropriate core specifications for these system scenarios. The scenarios are describing both the cell re-selection from GSM to UMTS and from UMTS to other radio access technologies.

Section 5.2.6, MS connected mode – Inter Radio Access System Handover scenarios, describes the system scenarios for connected mode and directs to the appropriate core specifications for these system scenarios. The system scenarios are

here e.g. “Reception of message XXXX by the UE”, “Reception of message INTER SYSTEM HANDOVER COMMAND by the UE” and “Abnormal case: UE fails to complete requested handover”.

This document can be considered as rather important as a reference document as it collects all relevant specifications for different procedures.

4.4.2 T2

In the report 3G TR 21.904 [33], the choice of radio access technology is introduced in a diagram in chapter 4 where the baseline definitions for a UE are described. The diagram makes the choice of radio access technology after searching for networks to register on. After a network is found the UE will decide what radio access technology/mode to camp on.

This procedure is the in line with what is proposed by this report, i.e. what is specified in other 3GPP groups and in ETSI SMG

4.4.3 T3

The requirement document for T3, 21.111 [34], collects all relevant requirements for the USIM and the IC Card. One section, section 11, is concerned with 3GPP/GSM interworking. The requirements deal with GSM subscribers in a 3GPP network and 3GPP subscribers in a GSM network.

4.5 Documents from ETSI SMG

The GSM part of the multi-mode UE is specified by ETSI SMG. This also applies for the procedures for handover and cell selection/re-selection from GSM to UMTS. The following specifications have been regarded most interesting in the respect to multi-mode UEs.

4.5.1 Functions related to Mobile Station (MS) in idle mode and group receive mode

This specification, TS GSM 03.22 [35], refers to the functions in idle mode and group receive mode for a GSM only MS. Examples of functions described are “PLMN selection and roaming”, “Camping on a cell”, “Barred cells and access -selection” etc. There are no references to the behaviour of a multi-mode UE as this specification was finalised before the UMTS specifications. Still these procedures and functions shall apply e.g when implementing the GSM part of a type 1 multi-mode UE. This specification has been the basis for the creation of the 3G specification 23.122 [1].

4.5.2 Radio subsystem link control

The specification TS GSM 05.08 “Radio subsystem link control” [7] addresses the following areas:

- Handover,
- RF Power control,
- Radio link Failure,
- Cell selection and re-selection in idle mode

The first and the last bullet point are most interesting as for the operation of a multi-mode UE. However this specification only deals with the general procedures for the GSM mode. For handover the MS measurement procedures are described and also the strategy for when inter-cell and intra-cell handover shall be performed, e.g., when the RXLEV and/or the RXQUAL is appropriate for a handover. For cell selection and reselection in idle mode the procedures in 03.22 [35] shall be followed but the measurements and some sub-procedures are described in 05.08 [7]. These procedures includes e.g. network pre-requisites (i.e. identification of surrounding BSS for handover measurements) and radio link measurements (such as signal strength, signal quality and how the measurements should be reported).

The specification gives the procedures for GSM and is not adapted at all to UMTS. The procedures for multi-mode Radio Resource Management are instead described in 25.104 [20].

4.5.3 Radio resource Control Protocol

TS 04.18 [36] describes the radio resource control protocol for the mobile radio interface at layer 3. As for handover the UTRA cells will be synchronised to, measured and reported back together with GSM cells according to the procedures defined in this specification and in 05.08 [7]. The UE is here responsible for making the measurements and to provide the means for reporting them back to the network.

4.5.4 Mobile Station (MS) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol

Another important GSM document to support multi-mode UEs are TS GSM 04.60 [37] which describes the interface between the MS and the BSS and the radio link control/medium access control (RLC/MAC) protocols for GPRS systems. Changes have been made to this document to provide for multi-mode functionality, but at the present stage the changes are not apparent to the editor.

5 Conclusions

5.1 General

A lot of work has been put down to clarify the types of multi-mode UEs. When combining the different modes there will be a lot of other combinations of UEs as the GSM mode encompasses circuit switched GSM and the different types of GPRS terminals. On the other hand the UMTS mode of the terminal can encompass FDD and/or TDD and in that mode just be capable of CS or PS services or have capabilities or both.

5.2 Identified requirements

A network entity that knows the users preferences concerning choice of radio access technology. This functionality is necessary to be able to direct the user to a preferred mode and if just network originated handover is possible.

5.3 Identified further work

For the transition of the same service to another mode, the identified transitions that need to be studied are:

State 1	State 2
UMTS PS	UMTS CS
UMTS PS	GSM PS
UMTS CS	GSM CS
UMTS PS	GSM CS
UMTS CS	GSM PS
UMTS PS	other access technology PS
UMTS CS	other access technology CS
UMTS PS	other access technology CS
UMTS CS	other access technology PS

These transitions can be done in either direction.

Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
15/03/00	7	TP-000027			Presented for approval to TSG-T#7. Not approved and renamed from 21.910 to 21.810	2.0.0	2.0.0
					Major changes in the structure and content of the report. The scope, section 4 and 5 redrafted and section 6 deleted. The former annex A deleted and replaced with section 7 as an informative annex. Editorial changes in the definitions and the references for cleaning up.	2.0.0	2.1.0
					The report divided into two, 21.910 and 21.810. The latter report includes the former annex of the old 21.810 and the introduction and the scope are changed accordingly.	2.1.0	2.2.0